British Columbia 2019 Lingcod Egg Mass Survey

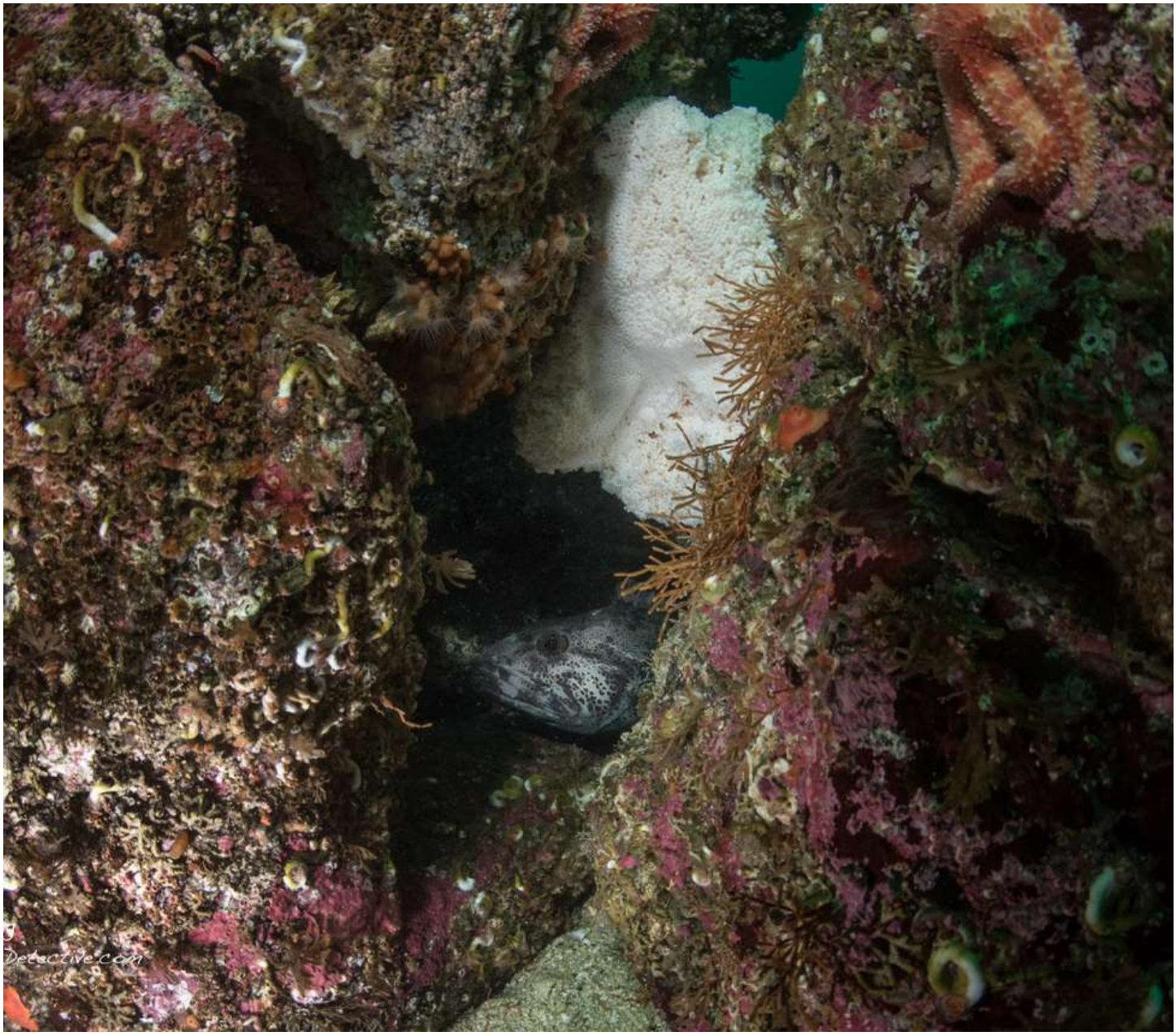

Photo: Jackie Hildering, theMarineDetective.ca

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A Brief History of Lingcod in British Columbia

Lingcod have an extensive history of commercial and recreational exploitation, and were once the fourth largest commercial fishery in British Columbia (Cass et al. 1990).Throughout the last century, lingcod have undergone biomass reduction from commercial fishing. In the late 1980s, lingcod stocks in the Strait of Georgia collapsed to approximately 3-5% of original biomass, with Howe Sound stocks reaching a low 1% of original biomass (Martell and Wallace, 1998). As a result, the Strait was closed to commercial fishing in 1990, with sport fishing regulations established in 1992. Even with these precautionary actions implemented, the depressed state of lingcod abundance was still a concern and thus Porteau Cove and Whytecliff Park were designated as a no-take closure area in 1993 under the Fisheries Act of Canada. In 2002, all sport fishing for lingcod was banned in the Strait of Georgia and surrounding waters. This ban was lifted on the east coast of Vancouver Island in 2006 but remains in place for the Vancouver area (area 28 and 29-1, 29-4 and 29-6 to 29-17).

In 2007 the Department of Fisheries and Oceans Canada (DFO) established 164 Rockfish Conservation Areas (RCAs) in British Columbia, in order to provide protection for BC's inshore rockfish populations (Yamanaka and Logan 2010), which are severely depleted following decades of unsustainable harvesting. These RCAs also provide protection for and assist in the recovery of local lingcod populations. Owing to extreme low abundance of lingcod in Howe Sound and Burrard Inlet, all hook-and-line fishing for groundfish (lingcod and rockfish) was banned in summer of 2007.

Lingcod spawn from December through to early April in the Strait of Georgia, with peak egg mass abundance in late February. The males guard the egg masses, which resemble styrofoam, for over a month until hatching. The behavior of the guarding male and the distinctive appearance of the egg masses are easily identified by SCUBA divers. Dives logged during the annual Lingcod Egg Mass Survey are performed by recreational divers as well as Ocean Wise® staff. Divers are enlisted through a variety of sources including dive organizations, stores, charters, magazines, and personal contacts. For the most part, dives by Ocean Wise® staff have been limited to Howe Sound.

Biology of Lingcod

Lingcod spawn primarily in January/February in crevices on rocky shores of western North America where strong currents allow for egg respiration (Cass et al., 1990). Eggs are adhesive to each other and resemble a clump of styrofoam. Females can begin to spawn at three years old and their egg masses are approximately one liter volume. A four-year female will lay an egg mass of about 2-2.5 liters, and then beyond five-years old, the fish lay much larger egg masses (Giorgi 1981). In 1995 reference sizes were created based on whether the egg mass resembled the size of a grapefruit (under one liter, from a 3-yr female), a cantaloupe (ca. two liters, from 4-yr female), or watermelon (5-yr or older). Most lingcod spawning occurs within a depth range safe for scuba diving (often between 15-60ft).

Most nests are guarded by the male parent, although smaller males tend to flee temporarily when approached by seals or divers. Smaller males may sneak in and partially fertilize some eggs during spawning, so a spawning reef often has more male lingcod than nests. The guarding male is the fish that attracted the female and initiated courtship and spawning, and is usually the principal sire of the egg mass. A dominant male may guard two or three adjacent egg masses, usually separately by no more than 1m (Cass et al., 1990).

The guarding behavior of the male parent tends to indicate the location of the eggs, which vary from white when newly laid to dark gray toward hatching. If the egg mass remains lodged in a crevice where currents force water flow through the eggs, and the male remains to prevent predation, embryos survive to the hatching stage of development.

Photo of male lingcod guarding egg mass.

Eggs incubate for 5-11 weeks depending on temperature and current flow (Cass et al., 1990). Hatch success varies with strength of currents: egg mortality occurs from respiratory failure in low flows. Newly hatched larvae swim rapidly to the surface, orient into currents and swim offshore by selecting stronger currents. This takes them into tidal current drift and rapidly disperses them through the spawning area. Little is known about the extent of larval dispersal, but over-fished areas do not seem to receive any rescue effect from spawning populations in remote areas. Adults are relatively sedentary, with only the females showing a seasonal depth migration for summer feeding.

Within two to three months of hatching, larvae settle at about 70 mm length and start feeding on juvenile herring. Lingcod reach 21 cm length in their first year, 30 cm at 20 months age, and 45 cm (0.8 kg weight) in their third year, as two-year olds (age 2+). Males grow rapidly until 8 years age, and live to a maximum of approximately 14 years. Females grow until 12-14 years age, and live to approximately 20 years. An age 13 male averages 84 cm and 6.1 kg, versus an age 13 female that averages 103 cm and 11.9 kg. The size record is 150 cm and 32 kg. Female lingcod of 10-12 years age are about twice the weight of males that age.

Survey Instructions

This year marked the 26th anniversary of the Lingcod Egg Mass Survey (LEMS). Initiated in the winter of 1994 by the Marine Life Sanctuaries Society (MLSS), the survey encourages divers from the community to census spawning of lingcod along the BC coast. Since 1996, Ocean Wise® has promoted and collated data for the census, encouraging a record number of participants.

The Lingcod Egg Mass Survey occurs over a five-week period centered on the third weekend in February, a time when most lingcod egg masses have been spawned but not much hatching has occurred. Divers are given an information packet that has all the pertinent information to complete the census; this packet is available online (https://research.ocean.org/survey/lingcod) or by contacting Ocean Wise® (fishlab@ocean.org). For each dive the following information is recorded:

Date - The month/day/year.

Diver Information - The first and last names of both divers and all pertinent contact information.
Area - There are 31 polygon areas we have divided the coast into; please note the appropriate area. Map provided on the website
Dive Site - Divers often identify sites by local names, which can make it difficult for us to know where the data were collected. Identify the specific location you are diving in and provide a GPS point if possible (ex: Whytecliff Park – Marker).
Bottom Time - Note the bottom time for your dive and if only a portion of the dive was spent looking for egg masses, note that time.
Comments - Be sure to record if no egg masses are found or if the dive was primarily on soft bottom (versus bedrock or boulders).
Nest Information
Depth – Note the depth where you found the egg mass in feet.
Size – Estimate if the egg mass is roughly the size of a Grapefruit, Cantaloupe or Watermelon (G, C, W).
Condition – You may want to bring a dive light along with you, this will aid in determining the condition of the egg mass. Recently extruded eggs will generally be white/pink (N=New). Older eggs will be eyed/dark grey (E=Eyed), or rotten (R=Rotten).
Situation – Note how the egg mass is situated, either loose (L) in a crevice, secure (S) in a crevice, or loose in the open (O).
Nest Guarding Male – Often one male may guard more than one egg mass. If the male is guarding only one egg mass, indicate so with a "P". If the male is guarding multiple egg masses, indicate so with "P2". If this is observed, record each egg mass as an individual egg mass and be sure to indicate the nest guarding male as "P2" for each egg mass. If there is an egg mass without a guarding male, indicate the absence of the male with "A".

Sample dive slate with nest information:

Nest #	Depth (ft)	Size	Condition	Situation	Nest Guarding Male
1	18	W	N	S	P2
2	18	W	E	S	P2
3	20	C	R	O	A
4	35	G	E	L	P
5	32	W	N	O	A
6	33	C	E	S	P

All data are sent to Ocean Wise® or entered online. Once we have sorted the data we calculate the index of abundance by using a Count Per Unit Effort (CPUE). The CPUE is the number of egg masses sighted per hour and is calculated by multiplying the number of egg masses by 60 to get an hourly sighting rate, divided by the dive time. Please return data reports promptly to ensure a timely summary report.

Results and Discussion

The 26th annual lingcod egg mass survey was conducted between January 25th and March 9th, 2019. Divers from all across British Columbia and Ocean Wise® staff undertook 137 dives totaling over 100 hours of underwater surveying. In all, 252 egg masses were seen by divers; over 45% of egg masses were seen in the Northern Gulf Islands, the area with the greatest number of surveys conducted (table 1).

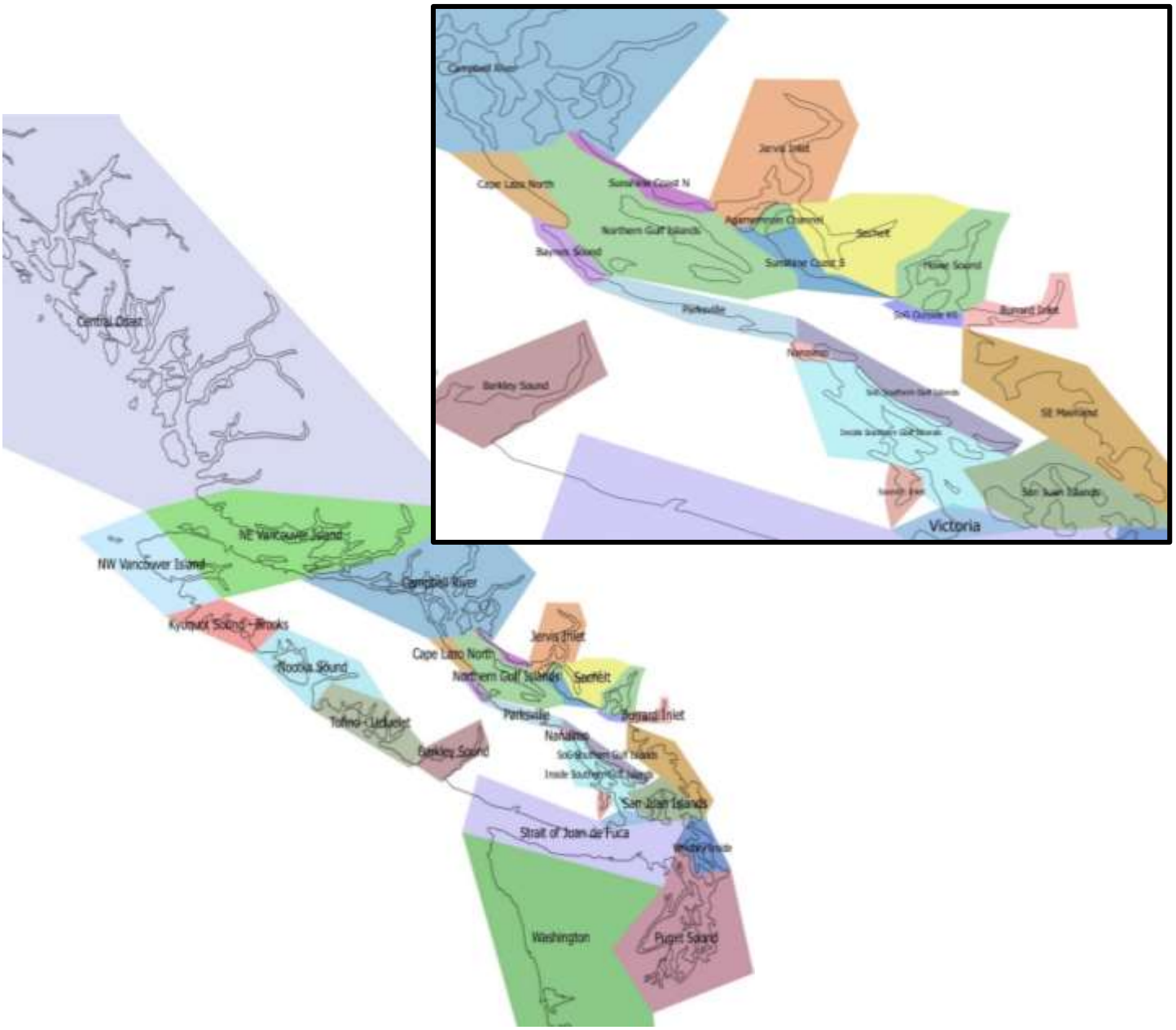

Figure 1. Geographic area breakdown for British Columbia south coast and Washington, comprised of 31 unique polygons. Areas are defined based on patterns from long-term biodiversity records.

Over the course of 26 years of surveying spawning lingcod populations in British Columbia's south coast, there is little indication of an increase in lingcod abundance. The 26-year average abundance of egg masses across all areas surveyed on BC's south coast is 4.26 egg masses h^{-1} survey (Fig. 2). The 2019 survey results are well-below the long-term average with divers recording an average of 2.31 egg masses h^{-1} (Fig. 2). It is notable though that the 2019 results are missing data from one site in northeast Vancouver Island that consistently averages over 20 egg masses h^{-1}. In spite of that, egg mass counts were down across all surveyed areas compared to 2018. Despite high levels of survey effort at many of the same dive sites surveyed in past years, divers were seeing fewer lingcod egg masses overall. In terms of age structure of the female population, the percentage of egg masses produced by the largest females – which produce the most viable larvae – has been ~50% over the course of the past 26 years, and 58% in 2019 (Fig. 3). Over the 26-year history of this survey the smallest age group of spawning females, which produce grapefruit size egg masses, represent less than 20% of the spawning female population, while 4-year-old females consist of 35-40% of the spawning population annually.

Despite there being no trend with regard to female spawning population structure (i.e.: a shift to a larger female population which could be an indicator for a healthier population), there are clear differences on a smaller geographic scale. Three areas had at least ten surveys contributed in 2019 to provide a sufficient sample size for comparison: Northern Gulf Islands, Parksville and Howe Sound. Of these three areas, only Howe Sound had an abundance of lingcod egg masses above the 26-year average, with divers recoding 5.40 egg masses h^{-1} (table 1.). Both Parksville and the Northern Gulf Islands were well below 2018 spawning levels despite effort and location being similar. Despite this abundance of egg masses in Howe Sound being above-average, only 67% of these egg masses were guarded by males. Northern Gulf Islands had a similarly low rate of male guarding at just 59%. The absence of a male lingcod guarding an egg mass greatly reduces the likelihood of eggs reaching the hatching stage. Without the male, it is likely that the eggs would be consumed by predators such as urchins or sea stars. By comparison, in northeast Vancouver Island where the spawning lingcod population appears healthy, egg mass guarding is frequently at or above 90%. The 2019 survey data for northeast Vancouver Island was well-below average, likely due to a lack of data from one of the healthiest lingcod sites as well as a change in survey effort. In general, at the sites located along northeast Vancouver Island that have been surveyed since 2000, the spawning female population has consistently produced large and numerous egg masses. Divers have noted egg masses that are twice the size of a watermelon, indicating they were produced by the oldest age class. This population of lingcod provides an important comparison for all other areas.

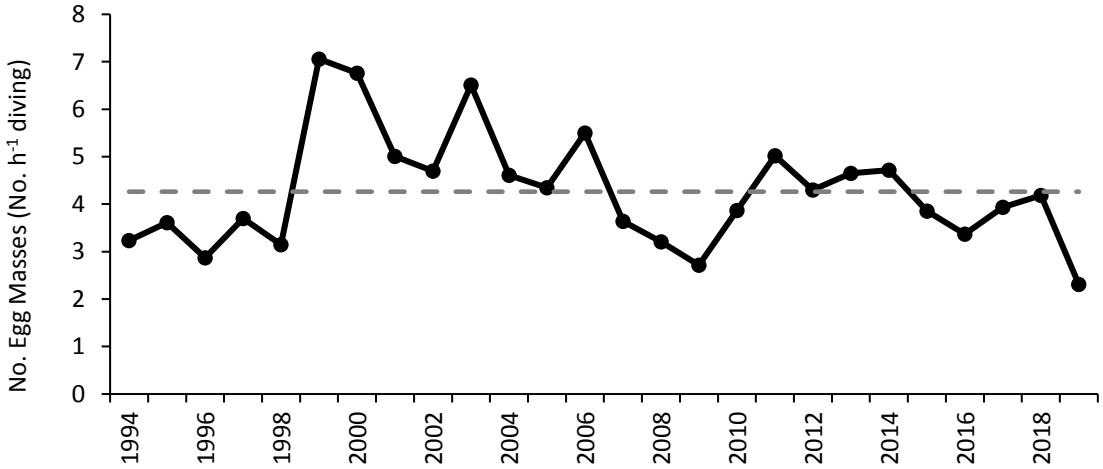

Figure 2. Abundance of lingcod throughout British Columbia's south coast since 1994, measured as the number of egg masses seen per hour diving. Solid line indicated average for each survey year. Dashed line indicates average egg masses over the past 26-years.

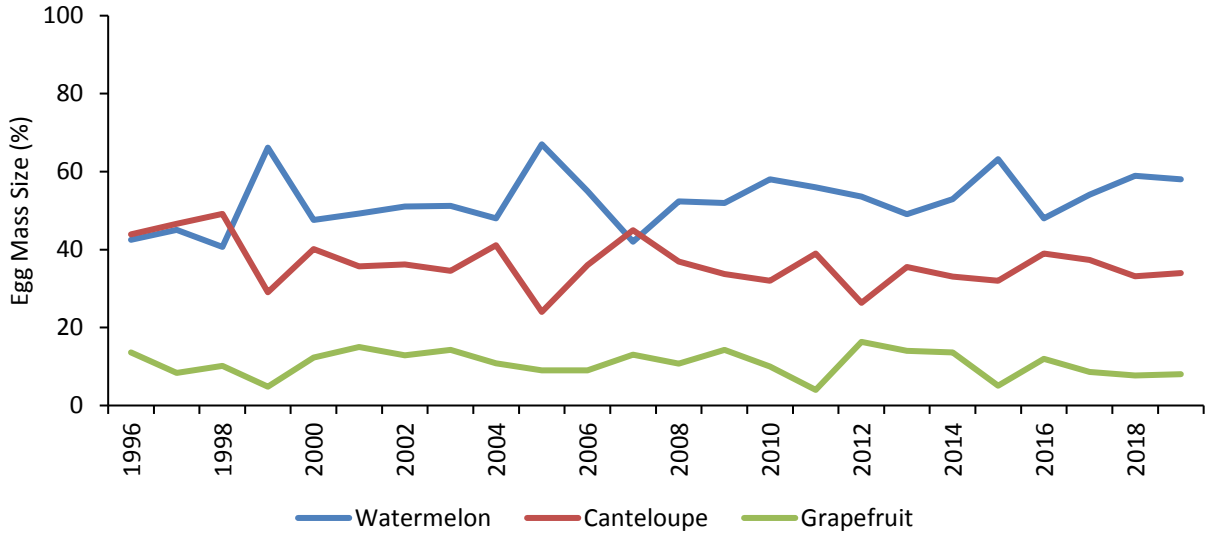

Figure 3. Percentage of egg masses produced by 5+ year old females (blue), 4-year-old females (red), and 3-year-old females (green) throughout British Columbia's south coast since 1994.

Selected sites

Lingcod have larger home ranges than rockfish, but are unlikely to stray more than 10km from where they settle as juveniles (Cass et al., 1990). Examining lingcod population abundance and spawning population structure at specific sites provides an opportunity to understand year-over-year changes on a much smaller geographic scale. We've selected four sites where data for this survey have been collected for at least ten years, representing three areas with an extensive survey history of the spawning lingcod population (Fig. 4).

At Whytecliff Park – designated as an MPA in 1993 – there has only twice been an abundance of lingcod in line with the average abundance over the past 26 years, one of which was 2019 (Fig. 4a). Most frequently there is only a single egg mass, and often none, at Whytecliff Park. With a low abundance of egg masses, it is difficult to discern any pattern in the age structure of the female lingcod population as determined by egg mass size. By comparison, the other MPA located further into Howe Sound, Porteau Cove, has seen between 5-10 egg masses h^{-1} since surveys began there in 1996 (Fig. 5b). Abundance of egg masses in 2019 was around average at 6.00 egg masses h^{-1}. Size distribution of egg masses at Porteau Cove is in line with overall survey averages, with approximately 50-60% of egg masses recorded as watermelon-sized.

At Nash Bank in the Northern Gulf Islands, surveys of spawning lingcod have been conducted since 2008. Egg mass abundance has been remarkably consistent over the past 11 years at this site, with an average of 2.73 egg masses h^{-1} survey in 2019 (Fig. 4c). Similar to the long-term average, Nash Bank has an average of approximately 50% watermelon-sized egg masses, while the least common size of egg mass is grapefruit. This particular site has been noted to have a large number of resident lingcod as the underwater topography provides excellent habitat for spawning lingcod.

In Saanich Inlet at Henderson Point surveys have been conducted on and off since 1998. With the exception of a few strong years, egg mass abundance has been relatively low, at less than 2 egg masses h^{-1} (fig 4d). In 2019 abundance of egg masses was 2.26 egg masses h^{-1}, a drop from the strong spawning numbers seen in 2018. Similar to the long term average of watermelon size egg masses for the entire BC coast survey area, watermelon size egg masses was slightly above 50% at Henderson Point in 2019.

What each of these individual sites demonstrates is the high variability in lingcod egg mass abundance we see among different areas along British Columbia's south coast. While few areas do consistently well and are populated predominantly by large females, many have significant year-to-year variation. There doesn't appear to be any indication of a shift toward an older female population for most of the areas surveyed. In order to see a significant recovery of lingcod stocks from the low reached in the 1990s, we would hope to see an increase in the number of large females which produce the greatest number of and most viable young.

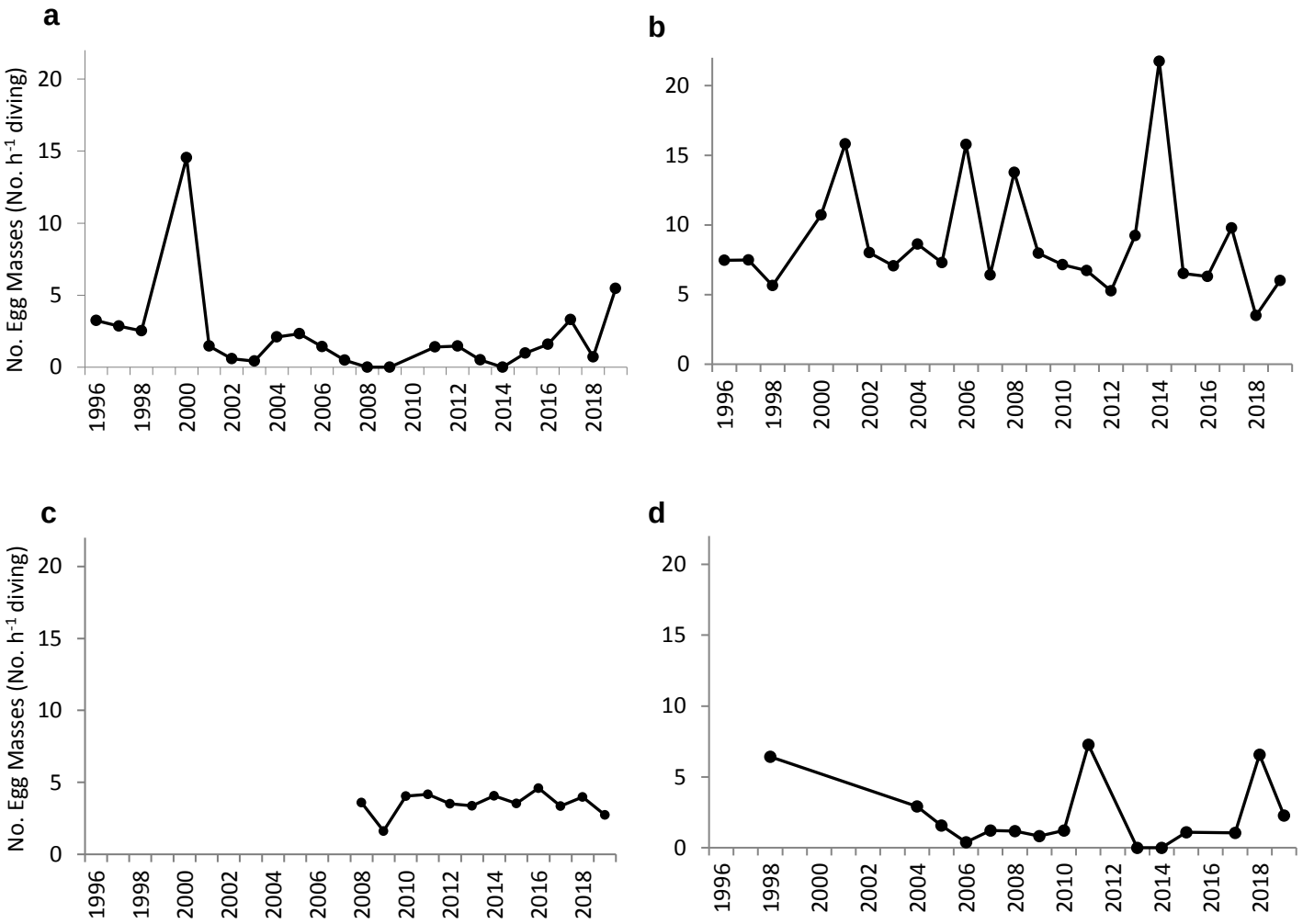

Figure 4. Abundance of lingcod egg masses (count per unit effort) since 1996 at (**a**) Whytecliff Park, and (**b**) Porteau Cove in Howe Sound, (**c**) Nash Banks in the Northern Gulf Islands, and (**d**) Henderson Point in Saanich Inlet.

Threats

The two main threats to lingcod population recovery are illegal fishing practices and predators, including seals and sea lions. Lingcod populations face pressure from recreation fishing likely due to a combination of lack of knowledge of fishing restrictions and difficulty of enforcement by the Department of Fisheries and Oceans (DFO). A 2005/2006 enforcement campaign along the Sea-to-Sky Highway by DFO coincided with an increase in egg mass abundance for Howe Sound in 2006. Whytecliff Park, despite being designated as an MPA in 1993, is a prime example of an area where frequent poaching has been seen. In addition to illegal fishing pressures, populations of harbor seals have increased in the past decade and are a potential contributor to the continued

suppression of lingcod spawning numbers, though no analysis of seal diets has been conducted since the 1980s for areas such as Howe Sound.

Solutions

In 2007,164 rockfish conservation areas were established along the British Columbia coast, which aim to protect BC's depleted inshore rockfish stocks and also lingcod. In addition, there is a complete commercial and recreational fishery closure for area 28 and parts of area 29 (Howe Sound and Burrard Inlet) for hook-and-line fishing for lingcod and rockfish. Follow the existing regulations for fishing in your area and report any violations to the Department of Fisheries and Oceans Canada (DFO: 1-800-465-4336).

How can you help?

Since its inception in 1994, the lingcod egg mass survey has been strongly dependent on divers from the community surveying rocky reefs for lingcod egg masses from January to March. What started as a citizen science initiative of the Marine Life Sanctuary Society remains largely dependent on contributions from the diving community. Divers can contribute to this survey by submitting their dives online during the annual Lingcod Egg Mass Survey (https://research.ocean.org/survey/lingcod).

The Lingcod Egg Mass Survey is not the only census the Coastal Ocean Research Institute's Howe Sound Research Program conducts. Since 2002, prior to the announcement of the first Rockfish Conservation Areas (RCAs) in 2004, researchers for Ocean Wise have been conducting Rockfish Abundance Surveys. Since 2013 the majority of contributions to the survey effort have come from citizen science divers throughout British Columbia. The Howe Sound Research Program promotes the Rockfish Abundance Survey (RAS) August – October annually. For more information visit the survey webpage: https://research.ocean.org/survey/rockfish

Please see the LEMS 2019 results table on the following page.

Table 1. Summary, by area, of lingcod egg mass sightings along the British Columbia south coast in winter 2019.

Area	# of Dives	Total Minutes	Total Egg Masses	CPUE	%W	%C	%G	% Secured	% guarded
Barkley Sound	8	399	14	2.11	86	14	0	86	79
Burrard Inlet	1	40	1	1.50	0	100	0	100	0
Howe Sound	26	678	61	5.40	54	33	13	89	67
Inside Southern Gulf Islands	2	105	1	0.57	0	100	0	0	100
Northern Gulf Islands	63	3312	115	2.08	52	37	10	80	59
NE Vancouver Island	3	90	3	2.00	100	0	0	100	33
Parksville	24	1425	40	1.68	70	30	0	90	78
Saanich Inlet	7	338	11	1.95	55	45	0	91	73
Victoria	3	148	6	2.43	50	50	0	83	50
all	137	6535	252	2.31	58	34	8	85	65

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